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EFFECT OF CALCIUM CARBONATE ON FLY ASH BASED BLENDED CEMENT CONCRETE

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ABSTRACT

This paper presents the effect of calcium carbonate (CaCO3) on blended cement concrete (BCC). The BCC was prepared with CaCO3 concentrations of 0.025, 0.075, 0.1, 0.2, and 0.3 g/l by adding in deionised water. In addition to this, control specimen was prepared with deionised water (without CaCO3) for the purpose of comparison. The setting times and compressive strength were evaluated for 28 and 90 days apart from studying rapid chloride ion permeability. The results show that as CaCO3 concentration increases there is retarding in initial and final setting of blended cement (BC). The compressive strength of BCC increases as the concentration of CaCO3 goes up at both 28 and 90 days. There is no significant change in compressive strengths of BCC. It was also observed that chloride ion permeability has decreased with an increase in the concentration of the CaCO3.

Keywords- *CaCO3, Setting time, Compressive strength, Chloride ion permeability.*

I. INTRODUCTION

In both fresh and hardened state of concrete, water is considered to be an important ingredient. Cement is a mixture of several complex compounds, the cement reacts with water and forms paste which leads to setting and hardening by hydration. All the compounds present in the cement are anhydrous, but when brought in contact with water, they get hydrolyzed, forming hydrated compounds. The quality of water is to be maintained strictly during the process of concrete making as the water helps to form the vital strength giving cement gel. Natural water is available abundantly in universe as a good solvent, but there are more chances of containing large number of impurities ranging from less to very high concentration. Many studies show more importance on properties of cement and aggregate, but the quality of water is often neglected.

In general scenario water used for concrete mixing is considered to be suitable if the water is potable i.e., if it is fit for drinking, it is fit for making concrete. This isn't true for all conditions. Sometimes, water contains a small amount of sugar would be suitable for drinking, but not for making concrete and conversely water suitable for making concrete may not be necessarily be fit for drinking, especially if the water contains pathogenic microbial contaminants. Research work has been carried out on effect of polluted/chemical water on hardened concrete strength and durability. The damage impact of various deicing chemicals and exposure conditions on concrete materials were studied by Kejin *et al.,* and results indicated that the various deicing chemicals penetrated at different rates in to a given paste and concrete resulting in different degree of damages [1]. Gorniniski *et al.,* presented an assessment of the chemical resistance of eight different compositions of polymeric mortars [2]. Adnan *et.al.,* reported the effects of environmental factors on the addition and durability characters of epoxy bonded concrete prisms [3]. Fikret *et al.,* investigated the resistance of mortars to magnesium sulphate attack and results reported that there is a significant change in compressive strength properties [4]. Venkateswara Reddy *et al.,* studied the influence of strong alkaline substances (Na_2CO_3 and $NaHCO_3$) in mixing water on strength and setting properties of concrete [5]. In many places ground water and surface water contains the impurities, more than that of limits specified by the IS 456:2000 [6]. Ali Reza Bagheri *et al.,* in their study on the effect of incorporation of silica fume in enhancing strength development rate and durability characteristics of binary concretes [7]. Erhan Guneyisi *et al.,* investigated the effectiveness of metakaolin (MK) and silica fume (SF) on the mechanical properties, shrinkage, and permeability related to durability of high performance concretes [8].

a) Research Significance

As there is scarcity of potable water in many places, this impure water is being used for mixing as well as curing of concrete in the civil engineering constructions. Hence an attempt is made to study the effect of water containing $CaCO_3$ at various concentrations in cements and their concretes.

b) Outline of This Paper

This paper includes the experimental program, selection of materials and test methods. Discussion of results and conclusions are presented.

II. EXPERIMENTAL PROGRAM

The influence of $CaCO_3$ at different concentrations was studied when the $CaCO_3$ is spiked with deionised water. Test samples were compared with the control samples. This comparison may not be possible in case of control samples made with locally available potable water since it varies in chemical composition from place to place. With the above reason, $CaCO_3$ was mixed with deionised water as per the dosage mentioned above. This water was used for preparation of test samples for determining the setting times (initial and final) of BC and compressive strength of BCC.

a) Materials

Portland Pozzolana cement containing 30% of fly ash was used in this investigation. The major chemical composition of cement used in the present study is presented in the Table 1. Locally available river sand was used as fine aggregate. Machine crushed granite stones of maximum size 20 mm confirming to IS 383:1970 [9] was used as coarse aggregate. Deionised water was spiked with $CaCO_3$ at different concentrations of 0.025, 2, 4, 6, 8, 10, 12 and 14 g/l.

Table 1. Chemical composition of blended cement

Sl. No	Parameter	Result
1	Insoluble Material (% by mass)	18.90
2	Magnesia (% by mass)	0.99
3	Sulphuric Anhydride (% by mass)	2.67
4	Loss on Ignition (% by mass)	2.04
5	Total Chlorides (% by mass)	0.001

b) Test Methods

The IS 10262:2009 [10] mix design was adopted for concrete mix. For determining the initial and final setting times of cement, Vicat apparatus was used as per IS 4031:1988 [11]. To assess the compressive strength of concrete, 30 concrete cubes of size 150 mm were cast and tested as per IS 516:1959 [12]. Rapid chloride permeability test (RCPT) was used as per ASTM C 1202 [13] to determine the chloride ion permeability of concrete, for which 15 specimens of size 100 mm x 50 mm were cast.

III. RESULTS AND DISCUSSION

a) *$CaCO_3$* effect on setting time of blended cement

The effect of $CaCO_3$ on initial and final setting times is shown in Table 2 and Fig. 1, from which it is observed that both initial and final setting times have got retarded with an increase in $CaCO_3$ concentration in deionised water. IS 456:2000 (Clause 5.4.1.3) [6] stipulates that, when the difference in setting time(s) is less than 30 minutes, the change is considered to be negligible or insignificant and if it is more than 30 minutes, the change is considered to be significant. From the experimentation work it is observed that, there is no significant change in the initial setting time at all concentrations. Significant change in final setting time is observed at relatively higher concentration, i.e., 0.2 g/l. When $CaCO_3$ content is 0.3 g/l (maximum), final setting time was 407 minutes which is 47 minutes greater than that of control mix.

Table 2. Setting times of blended cement (BC) corresponding to *$CaCO_3$* concentrations

Sl.No	Water sample	Setting time in minutes & Percentage change			
		Initial	% change	Final	% change
1	Deionised water (Control)	133	--	361	--

2	0.025 g/l	134	0.91	365	1.02
3	0.075 g/l	137	2.74	372	3.04
4	0.1 g/l	140	5.21	379	4.92
5	**0.2 g/l**	157	17.96	**395 ***	9.41
6	0.3 g/l	160	20.47	407	12.64

*Significant

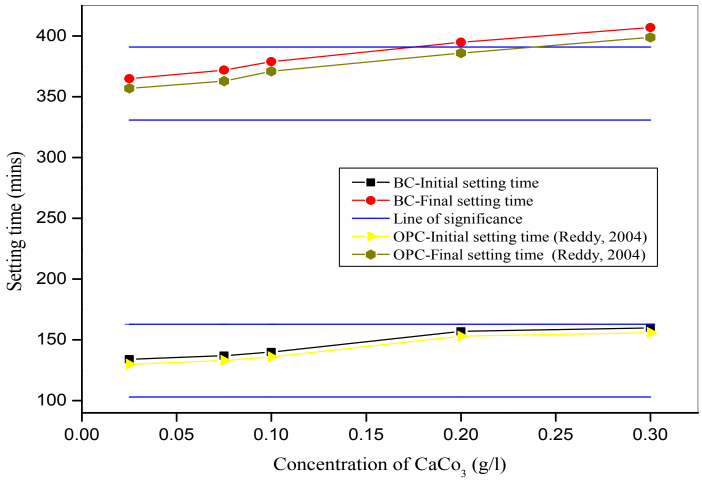

Fig. 1. Setting times of blended cement vs $CaCO_3$ concentrations

b) CaCO3 effect on compressive strength of blended cement concrete

The effect of $CaCO_3$ concentration on the compressive strength of BCC is presented in Table 3 and Fig. 2. The degree of variation in compressive strength is also presented in Fig. 3. The results indicated that there is a gain in compressive strength of the BCC irrespective of $CaCO_3$ concentration. In case of BCC, marked increase in 28 days and 90 days compressive strength is observed with increase in concentration of $CaCO_3$ but there is no significant change at any concentrations. Compressive strength for BCC, with $CaCO_3$ concentration from 0.025 to 0.3 g/l, has increased from 23.89 to 25.54 and 27.47 to 29.94 for 28 and 90 day aged specimen respectively

Table 3. Compressive strength of BCC corresponding to $CaCO_3$ concentrations

Sl.No	Water Sample	Blended Cement Concrete			
		Compressive Strength		% variation	
		28 days	90 days	28 days	90 days
I	Deionised Water (Control)	23.89	27.47	--	--
II i	0.025 g/l	23.98	27.60	0.36	0.49
ii	0.075 g/l	24.04	27.68	0.64	0.78
iii	0.1 g/l	24.25	28.05	1.49	2.11
iv	0.2 g/l	25.03	29.37	4.79	6.92
v	0.3 g/l	25.54	29.94	6.89	8.98

*Significant

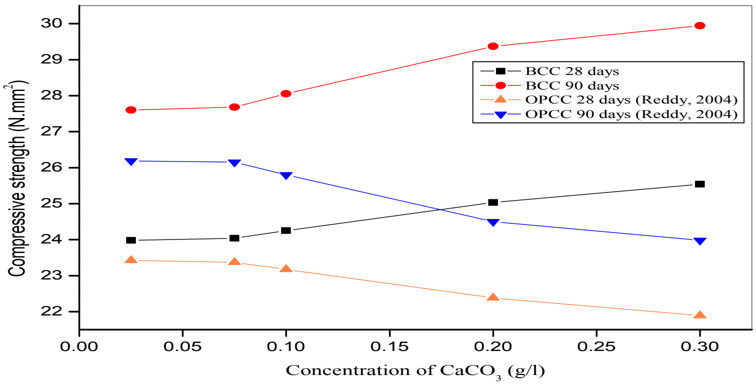

Fig. 2. Compressive strength of BCC vs $CaCO_3$ concentrations

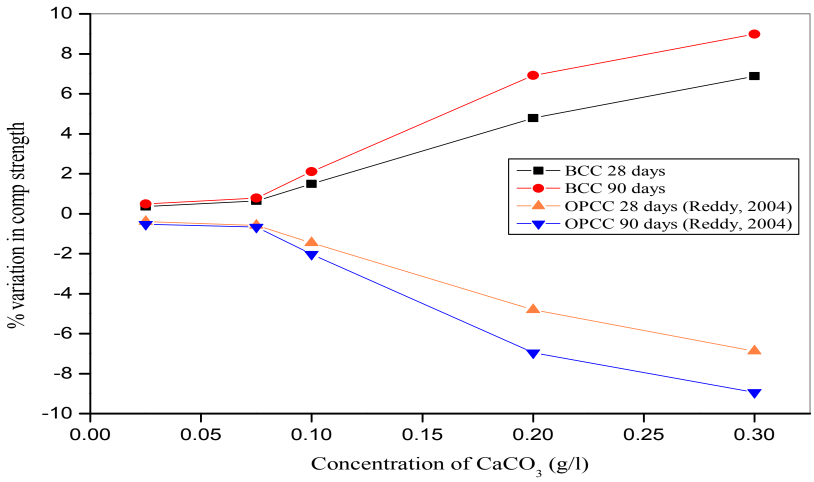

Fig. 3. % variation in compressive strength of BCC vs $CaCO_3$ concentrations

c) CaCO3 effect on Chloride ion Permeability of Blended cement concrete

The rapid chloride permeability levels in terms of coulombs passed through BCC observed are tabulated and listed in the Table 4 and Fig. 4. A glance at the said results establishes that the chloride ion permeability of the concrete studied has come down with the increase in the concentration of $CaCO_3$ up to 0.3 g/l which is the maximum experimented concentration. The degree of variation in compressive strength is also presented in Fig. 5.

Table 4. Chloride ion permeability in terms of coulombs passed in BCC corresponding to $CaCO_3$ concentrations

Sl.No	Water sample	Coulombs passed			
		28 days	% change	90 days	% change
1	Deionised water (Control)	2036		1187	
2	0.025 g/l	2018	-0.89	1180	-0.58
3	0.075 g/l	2004	-1.58	1175	-0.98
4	0.1 g/l	1975	-2.98	1155	-2.73

5	0.2 g/l	1947	-4.35	1098	-7.52
6	0.3 g/l	1889	-7.24	1072	-9.67

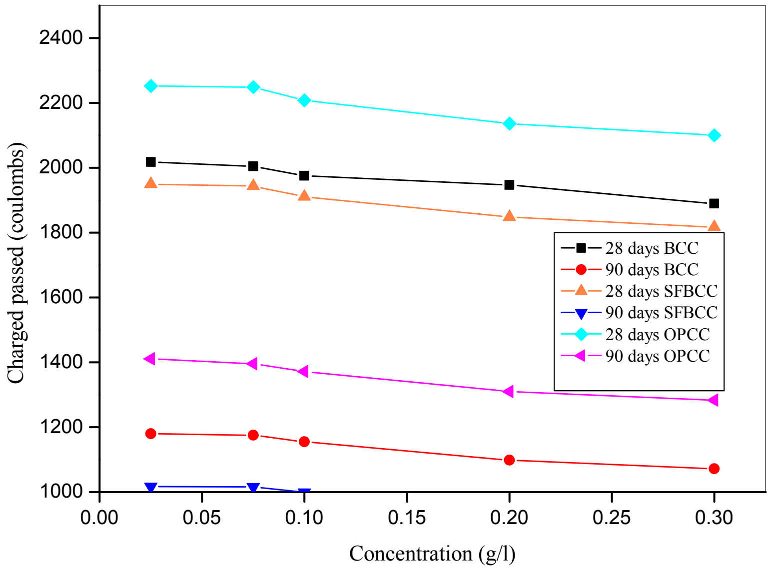

Fig. 4. Charge passed vs *$CaCO_3$* concentrations

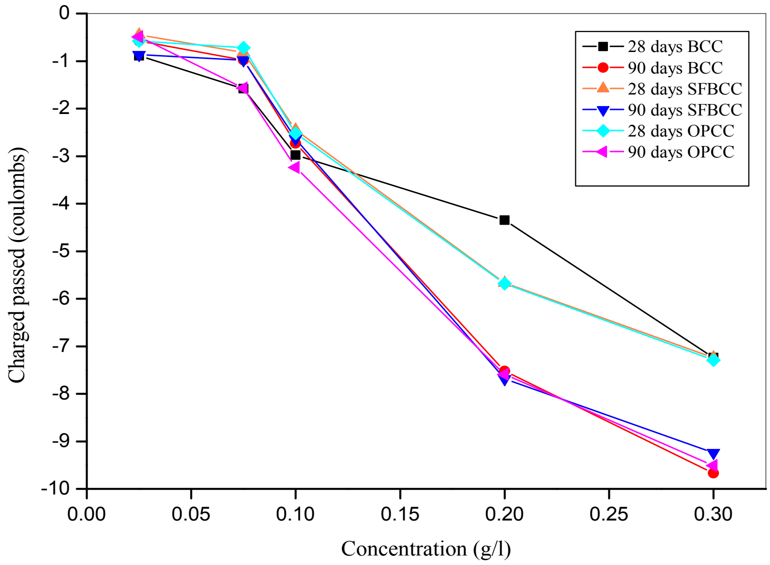

Fig. 5. %variation in Charge passed vs *$CaCO_3$* concentrations

d) Powder X-ray diffraction analysis

Powder X-ray Diffraction patterns shown in Fig. 6, 7 depicts BCC and SFBCC concrete cubes prepared with $CaCO_3$ (0.2 g/l) in deionised water. XRD pattern of BCC sample, at 28 days age, made with 0.3 g/l of $CaCO_3$ spiked in mixing water (deionised) is presented in Fig.6. Upper portion of the said graph indicates the XRD pattern of the control sample prepared with deionised water. A glance at these graphs establishes that the compounds such as C_2S, C_3S, Calcium Hydroxide (CH), C_3ACcH and C-H-S are found at $16^{0,}$ 17^0, 21^0, 47.4^0 and 37^0 respectively. Comparing with control sample, the sample of $CaCO_3$ additionally consists of C_3ACcH (Carbo Aluminate).

Setting times of the BC were observed to get retarded with the increase in $CaCO_3$ concentration in the mixing water. From the literature, carbonates are retarding the setting times. The same is observed when the $CaCO_3$ is added in mixing water in the present investigation. Possible reason is reaction between C_3A and $CaCO_3$ which produces carbo aluminate which retards the hydration process which in turn retards the setting times.

Compressive strength has increased with an increase in the concentration of $CaCO_3$. Chemical equation when $CaCO_3$ is added in mixing water with cement is given below. When $CaCO_3$ is added to mixing water, the same reacts with calcium silicates thereby extra C-S-H gel is generated which contributes towards extra compressive strength.

$3CaCO_3 + 3CaO.Al_2O_3 + 32H_2O \rightarrow 3CaO.\ Al_2O_3.CaCO_3.32H_2O$ (Carbo Aluminate)

In case of SFBCC also, compressive strength has increased with an increase in the concentration of $CaCO_3$. The XRD patterns of $CaCO_3$ added SFBCC powdered sample is presented in Fig.7. Reason elucidated above holds good here also for increase in strength, apart from addition of silica fume contributing towards an increase in compressive strength.

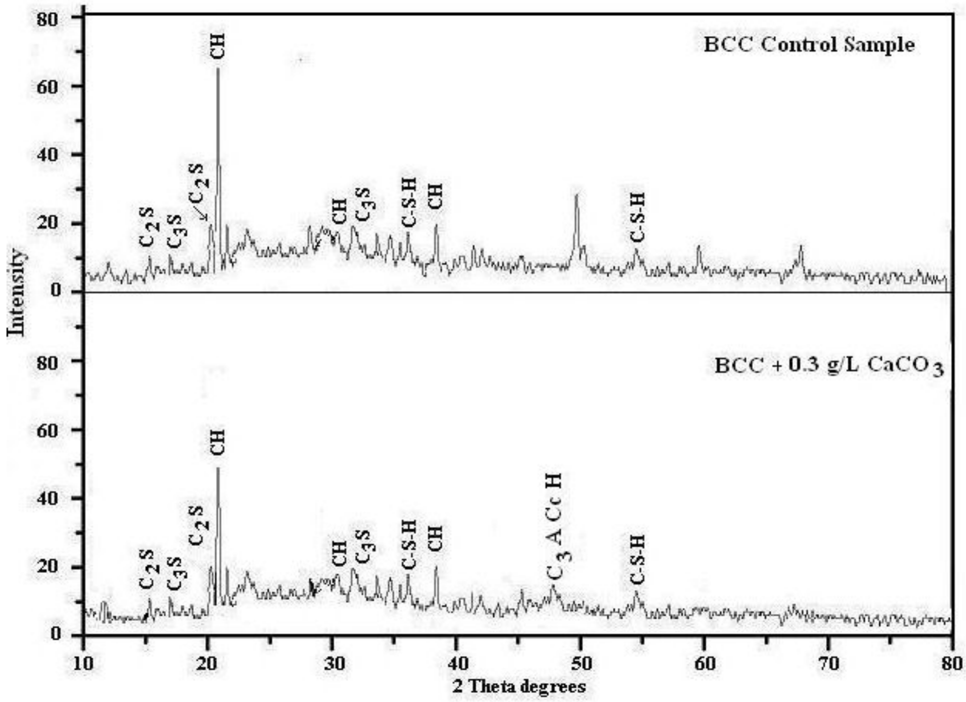

Fig.6: XRD pattern of BCC sample prepared with 0.2 g/l $CaCO_3$ in deionised water

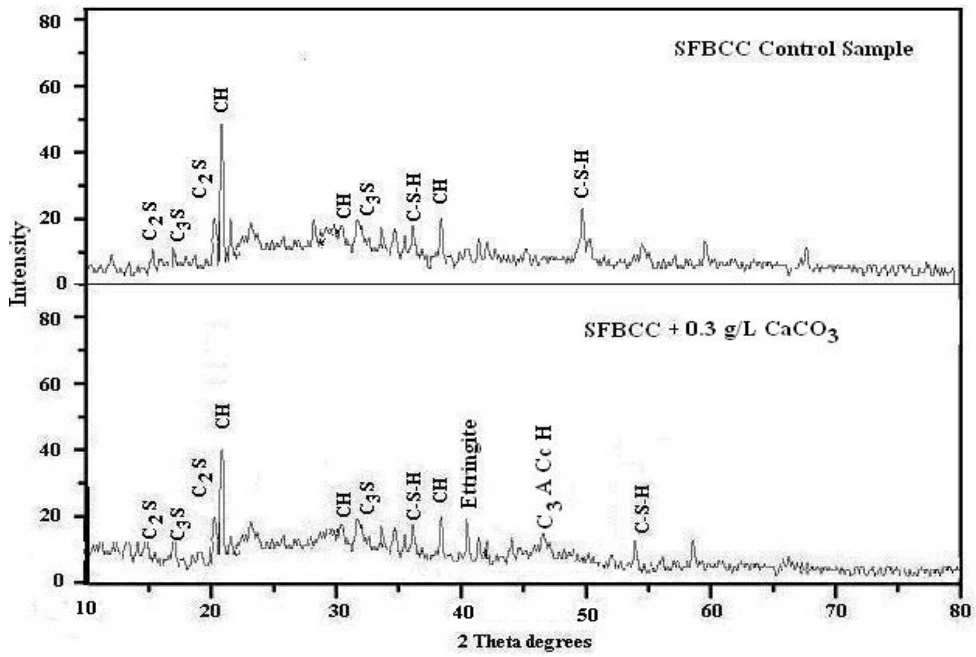

Fig.7. XRD pattern of SFBCC sample prepared with 0.2 g/l $CaCO_3$ in deionised water

IV. CONCLUSIONS

Based on the results obtained in the present investigation the following conclusions can be drawn:

It is observed that as $CaCO_3$ concentration increases, there is retarder in initial and final setting of blended cement (BC). The compressive strength of BCC increases as the concentration of $CaCO_3$ increases at both 28 and 90 days. Compressive strengths of BCC show a significant increase at 10 g/l when compared with the control specimens. It is also observed that chloride ion permeability has decreased with an increase in the concentration of the $CaCO_3$.

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